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ABSTRACT

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Attribution Theory and Mathematics Education

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Abstract

Causal attribution theory, including the concept of learned helplessness, has been used to explain student motivation and achievement in school. In this paper, a model is developed which explains how attribution theory could explain student effort and achievement in mathematics. According to the model, student perceptions of success or failure in mathematics are followed by attributions which then influence effort and finally achievement. Learned helpless or mastery oriented attributional styles are expected to develop when attributions are made in a consistent fashion over an extended period of time. Three directions for research relating attributions and mathematics education are also discussed. The first involves studies to validate the model, the second suggests new instruments, and the third deals with possibilities for changing students' attributional styles in mathematics.

Introduction: Attribution Theory and Mathematics Education

The study of student attitudes toward learning mathematics has been a common research topic over the past 25 years. In a majority of cases, however, researchers have only asked how attitude correlates with a certain curriculum or teacher behavior or whether attitude is significantly different from another variable being measured. An interesting but seldom explored question is that of how success and failure experiences in the mathematics classroom can lead to changes in students' attitudes and motivation. In this presentation, I will look at how students' perceptions of the reasons for their successes and failures in mathematics could affect their effort and thus achievement in mathematics. I will be taking what psychologists call "Causal Attribution Theory" and applying it to the study of mathematics. After briefly explaining the theory and presenting a model of how it should apply to mathematics education, I will also suggest research that could confirm or disconfirm the expected relationship between students' reactions to success or failure and their achievement in mathematics.

Causal Attribution Theory

Causal attribution theory deals with the reasons, or attributions, individuals give for succeeding or failing at a task. Because the correctness of a problem is usually clearly determined in school mathematics, it is easier for students to know when they are succeeding and when they are failing than it

is in other subject areas and thus attribution theory should be valid in the subject area of mathematics. Weiner (1972, 1974), building on the work of Heider (1958), Rotter (1966), and Kelly (1967) has proposed a theory for the attribution of causation of successes and failures that has been useful in non-content specific studies. According to his model, attributions vary on at least two parameters, internality and stability. When the parameters of internality and stability are crossed, a 2x2 matrix results as shown in Table 1.

Insert Table 1 about here

The cells of Table 1 were labeled with the following rationale. Events which are both internal and stable are perceived to be the result of a person's inner capabilities which Weiner (1972, 1974) called ability. Internal but unstable outcomes are the result of the effort a person puts out. External, stable outcomes vary as task difficulty and, according to Weiner, external, unstable events are simply the result of luck. The terms environment and others have also been used to label the external, unstable category in the matrix (Fennema & Peterson, 1984; Fennema, Wolleat, & Pedro, 1979). I have chosen to use "others" in this presentation as unusual help from a teacher, peers, or parents seems to be the most logical type of external, unstable attribution students would make in reference to success or failure in mathematics. Finally, let me stress that we are interested in how students perceive the causes of

their successes and failures, regardless of how correct those perceptions may actually be. As we move on to discuss the relationship between attributions and achievement, we will see that it is the students' perceptions of why they succeeded or failed that predict how success and failure will affect their future performances.

Learned Helplessness and Mastery Orientation

Most individuals are somewhat consistent in their attributions, and some types of attributions appear to have a more positive relationship to motivation and achievement than others (Covington & Beery, 1976; Weiner, 1979). I will now introduce the terms learned helplessness and mastery orientation to describe two categories of students (Dweck & Goetz, 1978). While learned helplessness and mastery orientation are more endpoints of a continuum than they are descrete classes of individuals, it is helpful to look for a moment at those individuals who appear to be predominantly learned helpless or mastery oriented in their attributional patterns.

The phrase "learned helplessness" was originated by Overmier and Seligman (1967) and Seligman and Maier (1967) who used it to describe the condition of laboratory dogs that received periodic electric shocks. The dogs, as would be expected, attempted to escape from their cages each time they received a shock but were prevented from doing so. After a period of time, the cages were changed so that it was possible for the dogs to escape but they

were so used to being unable to escape that they failed to realize that escape was possible. The dogs had learned they were helpless to control their own destiny. While we do not shock students in the way that Seligman and Maier shocked dogs, some students have come to feel that no matter what they do in school, they will fail. They feel that no matter how much effort they put forth they just are not going to do well. The term learned helpless has been applied to such individuals in academic settings (Covington & Beery, 1976; Dweck & Reppucci, 1973). In terms of Weiner's (1974) model of attribution, learned helpless students attribute their successes, infrequent as they may be, to the external factors of an easy task or help from others. Failures, on the other hand, are usually attributed to the internal and stable factor of low ability (Covington & Beery, 1976).

In contrast to the self-defeating attributional tendencies of learned helplessness individuals, mastery oriented persons are confident of their ability and thus are not worried about failure (Covington & Beery, 1976). Feeling that they are responsible for their own successes, they usually attribute success to possessing sufficient ability and effort to accomplish the task at hand while attributing failure to difficulty of the task or to lack of help from others. Such attributions, as we shall see, should lead to increased achievement in school.

Learned Helplessness, Mastery Orientation, and Achievement

To connect mastery orientation and learned helplessness with achievement, we must look to the connection between attributions and motivation to succeed in school and then assume that increasing students' motivation to succeed will lead to increases in their achievement. I will start by explaining how learned helpless attributions in the classroom are connected with a lack of effort on the part of the students.

Covington and Omelich (1979) state that students differentiate between effort and ability as determinants of success or failure in school. Theoretically, if failure is attributed to low ability, the student has no reason to expect to succeed at a later time as ability is perceived to be a stable cause of failure. Effort, on the other hand, is an unstable cause of failure. By attributing failure to lack of effort a student could expect success when effort was expended. This would be fine if the student tried harder but learned helpless students do not! The rational for this is as follows. If the student expended effort and still failed, the failure could only be attributed to low ability. As a learned helpless student fears evidence confirming that he or she has low ability, it is much easier not to try. In this way, failure can be attributed to lack of effort as opposed to lack of ability and preserve the student's desire to believe that he or she really does have ability.

Learned helpless students augment their low effort by the type of tasks they choose to do. When they have a choice of

tasks to work on, they are motivated to choose either very easy or very difficult tasks (Covington & Beery, 1976). On easy tasks, success is assured. When the student fails at a very difficult task, he or she can then attribute failure to the unreasonableness of the task and again avoid the feared conclusion that failure resulted from low ability.

Mastery orientation, as contrasted with learned helplessness, is connected with high effort on the part of individuals. Because success is attributed to the stable factor of sufficient ability, the individual knows that reasonable effort should lead to success on future tasks. Whereas learned helpless individuals fear that increased effort will still result in failure, mastery oriented students believe that increased effort will enhance their chances of success. If mastery oriented individuals fail, they do not doubt their ability and thus feel that lack of effort must be the cause. This attribution leads to even greater effort in school. Also, it should be pointed out that when mastery oriented students have a choice of problems to work on, they choose challenging yet reasonable ones as they do not worry about occasional failure. Hence, mastery orientation should be positively associated with increased student motivation and thus with increased achievement. Figure 1 summarizes the relationship between attributions, effort, and achievement for learned helpless and mastery oriented students.

Insert Figure 1 about here

In Figure 2, a simple linear model of how students' successes and failures in school are translated into effort is shown. The sequence of events described in the model is expected to occur each time a student completes an academic task (Kelley, 1973; Weiner, 1979). Attributions following the completion of a small task such as a single mathematical problem should have only a very small effect on effort on the next task. Attributions following subjectively more important tasks such as exams should have a greater impact on future effort. In general, over periods of semesters and years, the attributions students make are expected to substantially affect the amount of effort they will put forth in school.

Insert Figure 2 about here

An Attributional Model for Effort and Achievement on High Cognitive Level Mathematical Tasks

Although the model described in Figure 2 is a reasonable picture of how the attribution process affects achievement, a number of other factors also enter into the picture,

particularly when the model is applied to achievement in mathematics. In Figure 3, a more complete model of how students' perceptions of their successes and failures in mathematics class might be translated into attributions and then into achievement in mathematics is presented.

Insert Figure 3 about here

Looking at the model, we can see that it deals specifically with effort on high cognitive level mathematical tasks. A high cognitive level task is one which requires thinking and problem solving rather than algorithmic manipulation or simple recall. Operationally, high cognitive level mathematical tasks will be defined as understanding or application type problems as defined on the National Assessment of Educational Progress (NAEP) instruments (Carpenter, Corbitt, Kepner, Lindquist, & Reys, 1981). Attribution theory, as I have said, is applicable to a broad range of content domains. As minor differences in the application of the theory may apply between content domains, this model has been restricted to mathematics. In addition, attributions may vary somewhat for high as opposed to low level mathematical successes and failures and thus the model has been restricted to high level mathematical tasks.

The first two boxes of the model deal with completion of a high level mathematics task and perception of success or failure on that task by the student. This perception of success and

failure is then influenced by attribution mediators before a causal attribution is made.

Outside influence attribution mediators are instances of feedback from others that may influence one's attributions for success or failure. For example, a teacher may tell a student that failure was the result of poor effort or that success was the result of the problems being too easy. Parents and peers can similarly affect attributions and thus they have also been included as relevant outside influences.

Internal influence attribution mediators involve information and biases from an individual's past experiences and learning. Perception of sex role is particularly important for girls because if they see mathematics as more appropriate for boys, they may be less likely to think they have ability in mathematics. One study has indicated that mastery oriented individuals may not always make regular attributions (Diener & Dweck, 1978). If no attribution for success or failure is made after completing a mathematical task, that task completion will have no effect on effort until such time as an attribution is made. Past history of success and failure on similar tasks refers to information a person has collected over time. For example, if one teacher always gives inappropriate tests, then failure can be blamed on the task difficulty much more rationally than if the test covered the material discussed in class. Finally, as Blumenfeld, Pintrich, Meece, and Wessels (1982) and Nicholls (1978) suggest, age and thus developmental level of the student must be considered as children before about

the age of 11 do not appear to understand that ability and effort can be independent determinants of success and failure.

The next boxes in the model simply indicate that individuals make attributions for success, failure, or intermediate outcomes. It is these attributions, as modified by the attribution mediators, that can gradually change a person's position on the mastery orientation/learned helplessness continuum.

The last boxes in the model show that the amount of mastery orientation a person exhibits is expected to affect his or her effort on all future mathematical tasks. Value of the task, however, must also be included (Atkinson, 1964) as people are unlikely to work very hard on problems or exams where success is of little value. Finally, students who exert effort are expected to achieve more highly than those who do not as effort is necessary for success on any challenging task.

In short, the model shown in Figure 3 attempts to explain how perception of success or failure on one high level mathematical task will lead to effort on similar tasks. Attribution mediators affect the causal attribution which affects mastery orientation which affects effort. It is expected that increased effort will lead to increased achievement. While one cycle through the model will have little effect on achievement, over a period of months and years the model should account for significant differences in the achievement of students.

Directions for Attributional Research in Mathematics Education

Three areas for research on attribution theory as it relates to mathematics education appear to be the most promising. The first deals directly with validation of the model presented in Figure 3. If the model is reasonable, then one would expect that students' attributions would be correlated with their achievement and that attribution mediators such as the influence of present and past teachers would be important. It is also reasonable to expect that development and change of students' attributions would follow the process outlined in the model. Thus, the first question one might consider is:

1. To what extent do attributions for success and failure in mathematics correlate with learned helplessness, effort, and achievement in mathematics?
    a. At what grade levels are the relationships strongest?
    b. How do students' attributions for success and failure in mathematics change over time?
    c. How important are attribution mediators such as teacher feedback and past history?

To address this question we need to collect data on several of the key variables in the model. I have recently been measuring attributions and achievement among ninth-grade algebra

I students. Those data have not been analyzed but they should shed some light on the question of whether or not mastery oriented attributions are more prevalent among higher achieving students and whether or not learned helpless attributions are more prevalent among lower achieving students. Because students' ability to make attributions and interpret them as we have done here does not appear to develop before about grade 4 or 5 (Blumenfeld et al., 1982; Nichols, 1978), one must ask how influencial attributions could be before that time. A longitudinal study of students' attributions would give us a much clearer picture of how attributions develop and change and at what age level attributions begin to have a noticeable affect on achievement. The importance of teacher feedback on the attributional process, while difficult to measure, also affects the development of mastery orientation and thus should be studied. Inherent in the discussion of any of these questions however, is the problem of accurate measurement of attributions for success and failure in mathematics. This brings us to the second area where I would suggest research relating attribution theory and mathematics learning.

At the present time, there are several instruments to measure students' attributions for success and failure in mathematics (see Fennema & Peterson, 1984; Fennema et. al., 1979; and Parsons, 1980). None of these scales have been widely used although there is a reasonable amount of data available on the Mathematics Attribution Scale (MAS) for middle school and high school students (Wolleat, Pedro, Becker, & Fennema, 1980).

All of these scales were developed for studies designed primarily to find out where sex-related differences in the learning of mathematics occur rather than to study the attribution-achievement link suggested by the model I have proposed. Thus, it is reasonable to ask:

2. How do students' scores on various attribution instruments compare?

   A. What type of instrument best documents the expected link between attributions and achievement in mathematics?

The scales described above all measure students' attributions via the self-report method. An interesting complement to this would be to look at student performance in success or failure situations under the assumption that certain attributions should be connected with effort while others should be connected with lack of effort. Such an approach has been tried in two psychological studies of learned helplessness (Diener & Dweck, 1978; Dweck & Reppucci, 1973). In these studies, students were given unsolvable puzzles to induce failure and then given solvable puzzles to see whether they gave up in a manner similar to Seligman's dogs. I have been using a similar procedure in my work except that I have been using very difficult, although solvable, and moderately difficult mathematics word problems. The data have not yet been analyzed but this appears to be a productive method of assessing students' reactions to a type of failure which is not uncommon

on high cognitive level mathematics tasks. More work needs to be done, however, on both self-report attribution scales and on performance following failure scales. Only then will we be able to say for sure that students' attributions influence their mastery orientation/learned helplessness which then affects their achievement in mathematics.

The final area for research I would like to suggest involves the possibility of changing students' attributions through a training program. Specifically:

3. Would an "Attributional Retraining" program increase student achievement for unusually learned helpless students?

A study by Dweck (1975) showed that teaching unusually learned helpless students between the ages of 8 and 13 to attribute failure to lack of effort resulted in significant performance gains on computation problems. While the study was done on a small scale, one must wonder if a training program for learned helpless students could be designed and implemented on a broader scale and whether such a program would be useful in improving performance on high level mathematics tasks. If students were taught as part of the retraining about the attributional process itself, would it make it easier for them to overcome their learned helpless conditioning? Determining all the proper topics for an attribution retraining program would require extensive work but if data on attributions, effort, and achievement as outlined in question 1 showed the model I've

proposed to be valid, it may be worth attempting an attributional retraining program in mathematics on at least an experimental basis.

As a summation of this paper, I would like again to stress that while attribution theory and learned helplessness theory have support from the psychological literature, the constructs have not been extensively tested in mathematics classrooms. The model that I have presented appears reasonable but much needs to be done to show that it actually does help explain achievement differences in mathematics. If the model, or portions of it, are validated through some of the research I have suggested, we will have gone a long way in showing that not only do students have feelings about mathematics, but indeed those feelings do result in changes in students' effort and thus achievement in mathematics.

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Table 1

Attributions for Success and Failure

(Adapted from Weiner, 1974)

Stability	Internality	
	Internal	External
Stable	Ability	Task Difficulty
Unstable	Effort	Others

Figure 1

Attributions, Expectations, and Effort for Learned Helpless and Mastery Oriented Students

Learned Helpless Students

Attribution	Expectation of Success	Effort on Similar Task
SUCCESS attributed to:		
1. Ease of Task (External)	→ No reason to expect success on tasks of reasonable difficulty	→ No reason to put forth effort
2. Others (External, Unstable)	→ No reason to expect help and thus no reason to expect success	→ No reason to put forth effort
FAILURE attributed to:		
1. Lack of Ability (Internal, Stable)	→ No reason to expect success on similar task	→ No reason to put forth effort
2. Lack of Effort (Internal, Unstable)	→ Unsure of success on similar task	→ Continued low effort (to avoid finding out whether low effort or low ability was the cause of the failure)

Mastery Oriented Students

SUCCESS attributed to:		
1. Ability (Internal, Stable)	→ Expectation of success on similar tasks	→ Continued effort
2. Effort (Internal)	→ Expectation of success on similar tasks	→ Continued effort
FAILURE attributed to:		
1. If task seemed reasonable, attribute to lack of Effort (Internal, Unstable)	→ Expectation that increased effort will lead to success	→ Increased effort
2. If task seemed unreasonable, attribute to difficulty of task (External)	→ No reason to expect failure on a reasonable task	→ Continued effort

Figure 2

Attributions and Effort Following a Success or Failure in School

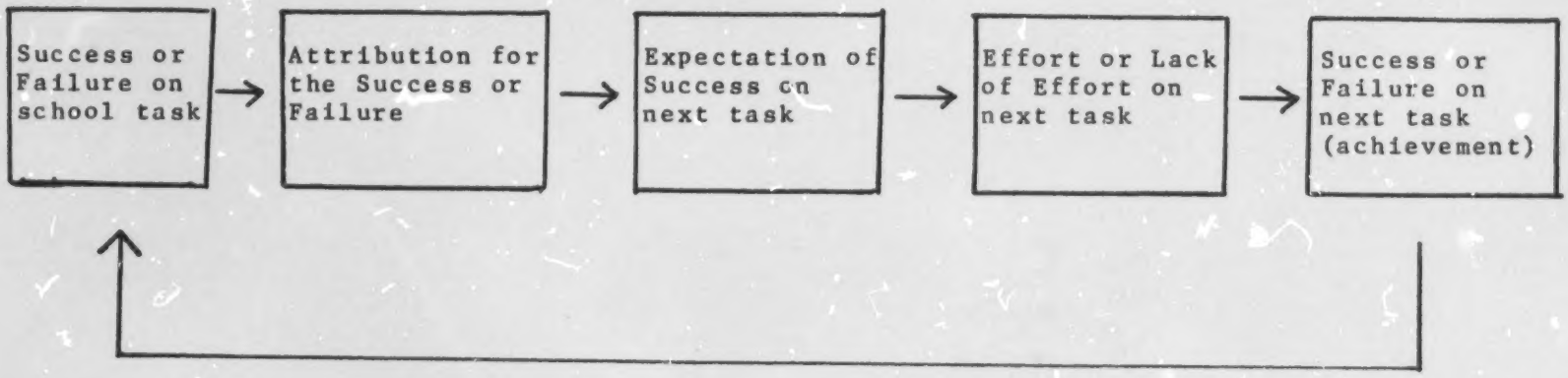
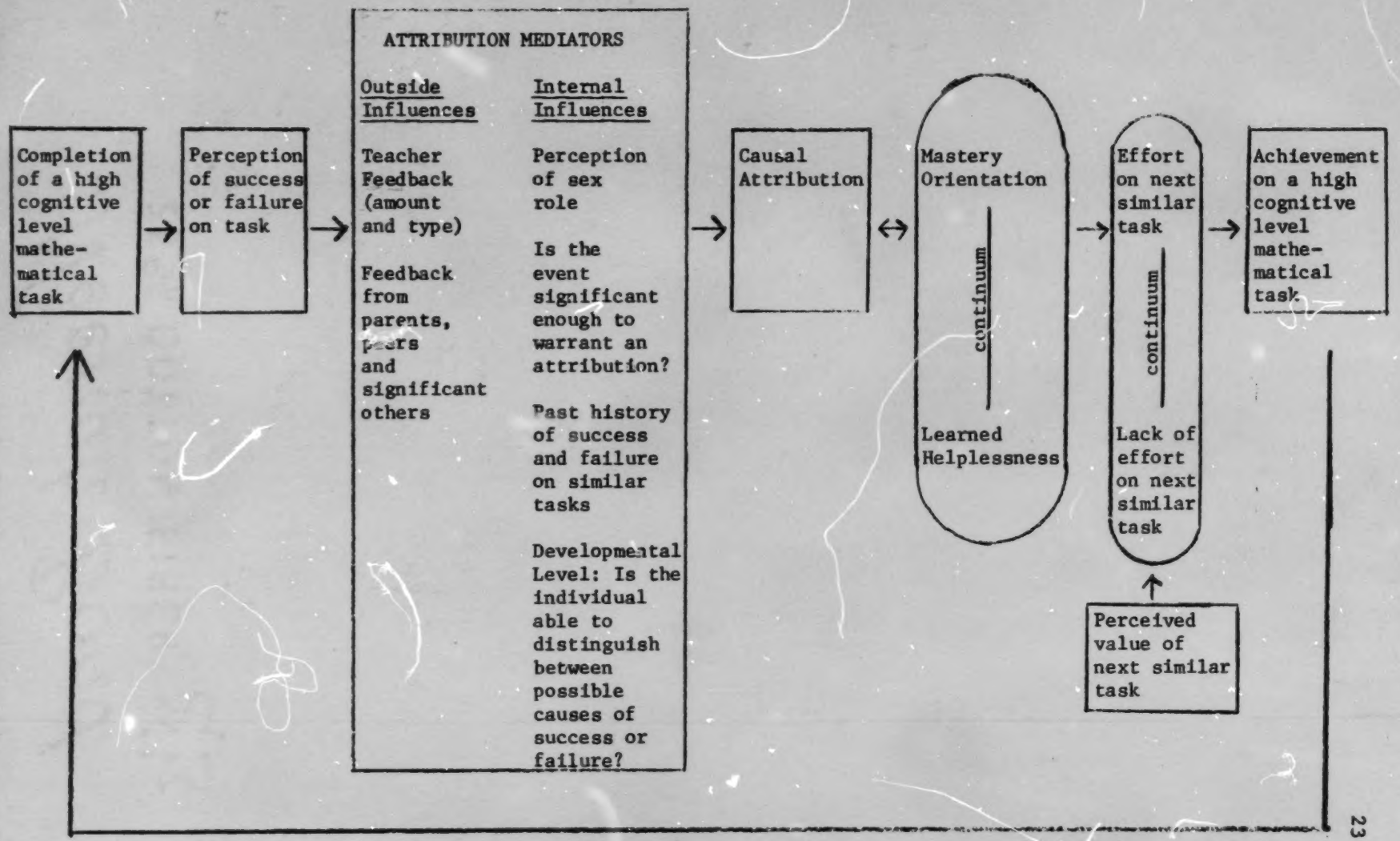

Success or Failure on school task
Attribution for the Success or Failure
Expectation of Success on next task
Effort or Lack of Effort on next task
Success or Failure on next task (achievement)

Figure 3

An Attributional Model for Effort and Achievement on High Cognitive Level Mathematical Tasks


Completion of a high cognitive level mathematical task
Perception of success or failure on task
ATTRIBUTION MEDIATORS
Outside Influences
Teacher Feedback (amount and type)
Feedback from parents, peers and significant others
Internal Influences
Perception of sex role
Is the event significant enough to warrant an attribution?
Past history of success and failure on similar tasks
Developmental Level: Is the individual able to distinguish between possible causes of success or failure?
Causal Attribution
Mastery Orientation
continuum
Learned Helplessness
Effort on next similar task
continuum
Lack of effort on next similar task
Perceived value of next similar task
Achievement on a high cognitive level mathematical task